A glimpse at the first results of the AutoBehave project: a multidisciplinary approach to evaluate the usage of our travel time in self-driving cars

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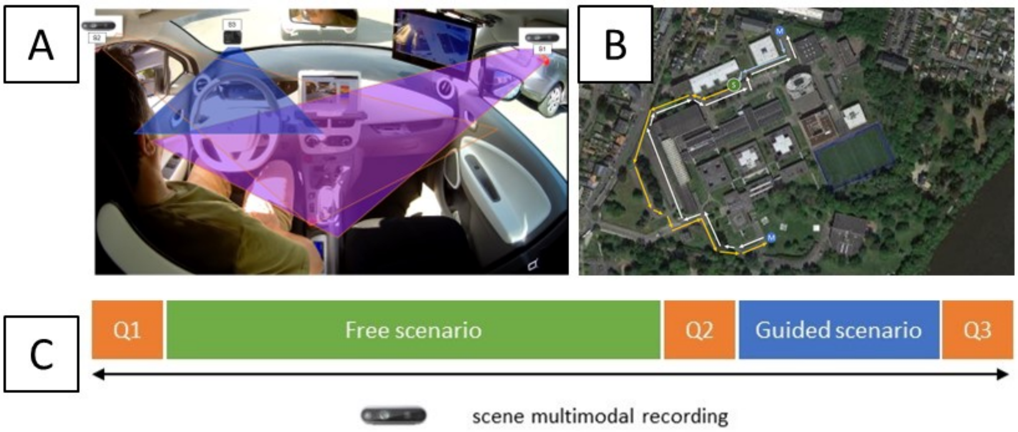

Figure 1: Proposed multidisciplinary, multi-sensor framework. A) Acquisition module, B) Experimental path on the campus of Ecole Central de Nantes, C) Timeline and scenarios of the experimental framework.

Introduction: The advances in self-driving technologies will certainly revolutionize our lives. The first robot taxi services are already present in certain cities of the world (*e.g.*, WAYMO in San Francisco). Without surprise, most work related to self-driving cars (SDC) focuses on improving the way an SDC navigates and interacts with other road actors (*e.g.*, pedestrians, cyclists, other vehicles). However, what happens in the cockpit of SDCs is little explored. Existing work focuses on situations where the driver is asked to take back control of the vehicle. We currently lack tools, and datasets to analyze the behaviors of the occupants of SDC in outdoor conditions, and beyond driving-related

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actions [1]. For instance, most computer vision datasets devoted to monitoring the cockpit of SDCs of SAE[1] level 4 (high automation) consist of synthetic data [2–4] or are based on laboratory recordings [5]. Besides, studies in human and social sciences, such as cognitive sciences and economy of transport are usually focused on declarative surveys and/or evaluated on dedicated infrastructures, such as cockpit simulators [6, 7].

Contribution: We propose a multidisciplinary, multi-sensor framework named Auto-Exp to evaluate how the occupants of SDCs use their travel time in real-world conditions, in particular concerning non-driving actions.

Materials and methods: The proposed framework is composed of an experimentation scenario (Fig.1C), and an acquisition module (Fig.1A). The experimentation scenario is composed of two parts: the free and the guided scenarios. The free scenario seeks to capture the natural (non-guided) actions of the occupants of a vehicle during their usage (or discovery in our case) of the SDC. The guided scenario takes place after the free scenario, and it consists of the realization of a series of actions using the objects put at the disposal of the participants. Its main goal is to collect a video dataset for the development of video analysis tools. The acquisition module is composed of two RGB-D sensors (Intel RealSense D435) and a GoPro camera. RGB-D sensors are attached to the top corners of the windshield and capture a lateral view of the body of people in the front seats. The GoPro camera records a close view of the upper body of the person in the driver's seat. We also ask participants to fill out declarative surveys about their internal states (IT) and their acceptance of this new means of transportation (ASDC). We applied the surveys before (ASDC+IT), during (IT only), and after the use of the vehicle (ASDC+IT).

Experiments: To evaluate the proposed framework, we carried out a four-day long experiment in July 2021 using a Renault Zoe car (electric supermini urban model) on the campus of the Ecole Centrale de Nantes (ECN) in France. The vehicle was robotized by the LS2N-ARMEN laboratory to behave as an SDC of SAE level 4 [8]. Participants were recruited based on their declared interest to test the SDC technology during their participation in a prior, online survey on people's attitude towards SDCs [9], or in response to recruitment advertisements posted to the employees and the students at the university. Participants occupied the driver's seat of the vehicle. A safety driver was present in the passenger front seat using a dedicated interface to take back control of the car in case of need. An experimenter was also present in the back seat to guide the experiment. The vehicle traveled over a predefined path over the streets and the parking of the ECN campus (Fig.1B) and automatically adapted its trajectory in response to the road conditions. Each participant's experiment consisted of five laps in the predefined path (8 km in total). The free scenario took place on the first three laps (4.8 km on average), and the guided scenario took place during the last two laps (3.2 km on average). During the free scenario, participants were instructed to behave as they feel like. They could perform actions with objects they brought with them or with objects put at their disposal, or simply watch the experiment unfold idly. During the guided scenario, the experimenter asked participants to realize a set of actions. The instructions were brief, so the participants would have the liberty to decide how to perform the actions. We created the list of target actions based on previous studies about autonomous vehicles. [5, 9]. Examples of action instructions are "use the phone", "read a newspaper", or "listen to music". The experimenter chose randomly the order of guided actions, as well as their duration.

Results: We acquired a multidisciplinary, multi-sensor dataset composed of 29 partic-

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ipants (18 male/11 female) conducting non-driving actions related to a common commuting routine on an SDC of SAE level 4. Video recordings are 1 hour long and are associated with surveys about participants' internal states and attitudes toward SDC. The acquired dataset successfully depicts a large variety of sources of noise, both in terms of sensor data and action realization. The observed types of noise are common in real-world scenes but are currently absent in previous datasets. Recruited participants presented a variety of body sizes, ages, and education levels. The acquired dataset, named AutoBehave, will be released progressively on the project website[2] under the form of computer vision tasks (*e.g.*, pose estimation, action recognition) and multidisciplinary studies (e.g., the analysis of the internal states of SDC's users to estimate their comfort, the study of the value of the user's time in this new type of vehicle).

Conclusion: We proposed a novel framework to study how occupants of SDCs use their travel time by analyzing their actions, internal states, and attitudes toward this kind of vehicle. We demonstrated its usage by collecting a multidisciplinary dataset depicting the non-driving actions of people during the test of an SDC traveling in an outdoor environment. Future work will focus on developing methods to analyze the acquired data automatically and on the study of the acquired dataset in a multidisciplinary fashion.

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